

This is a post-print version of:

R. Douglas Brubaker and Claes Lykke Ragner
'A review of the International Northern Sea Route Program (INSROP) – 10 years on'
Polar Geography, Vol 33, Nos 1-2, 2010, pp. 15-38

The definitive version is available at <http://dx.doi.org/10.1080/1088937X.2010.493308>

A review of the International Northern Sea Route Programme (INSROP) – 10 years on

R. DOUGLAS BRUBAKER* & CLAES LYKKE RAGNER

Fridtjof Nansen Institute, P.O. Box 326, 1326 Lysaker, Norway

* Corresponding author: Email: douglas.brubaker@fni.no

Abstract: The objective of the International Northern Sea Route Programme (INSROP) was to create a knowledge bank covering commercial, international shipping on Russia's Northern Sea Route (NSR). Addressed were: considerations of the natural environment, ice navigation and ship technology; the environment; economics of shipping; and military, political, legal and indigenous cultural issues. Conclusions included improvements in vessel designs and associated activities represented the safe course for extending navigation. Scientific evidence generally did not exist that civilian navigation had resulted in significant environmental stress; the NSR thus could plan for environmental concerns and avoid devastating impacts. It was necessary for the Russian government to include the NSR in plans for its extractive industries. There were resource commodities well-suited for creating a sustainable cargo flow, but the necessary domestic and foreign investments would have to be provided. The NSR lacked strategic and military importance and held solely civilian, commercial potential. Except for the high seas, the U.S. would require its commercial vessels to follow the Russian regime, including fees if not discriminatory and for services rendered. For indigenous cultures NSR effects could be both positive and negative; primary was the need to be included in creating the NSR framework and indigenous perspectives viewed and treated equally.

1. Introduction

The International Northern Sea Route Programme (INSROP) was probably one of the most comprehensive studies of Arctic marine transport ever undertaken. The aim of this 1993–1999 multi-disciplinary endeavour was to create a research based knowledge bank covering all aspects of commercial, international shipping on Russia's Arctic Northern Sea Route (NSR). This objective was accomplished by the cooperation of 468 researchers and experts from more than 100 institutions in 14 countries. These conducted 104 projects in addition to an experimental voyage through the NSR and organizing two, large international conferences. This work produced 167 peer reviewed working papers and a large number of articles and books covering almost every conceivable aspect of shipping on the NSR¹. A total of approximately NOK 56.5 million² was used in the course of INSROP, with roughly half provided by the Nippon Foundation/Ship & Ocean Foundation, most of the remainder was provided by various Norwegian sponsors, and some additional funding provided by the Russian Federation.³ The programme was led and coordinated by three principal partners, the Ship & Ocean Foundation (SOF) of Tokyo, Japan, the Central Marine Research and Design Institute (CNIIMF) of St. Petersburg, Russia, and the Fridtjof Nansen Institute (FNI) in Lysaker, Norway.

As part of policies to open the Soviet Union, President Mikhail Gorbachev in 1987 announced intentions to allow foreign vessels access to the NSR that could be used both as a shortcut for transit traffic between the northern Atlantic and the northern Pacific, as well as for export of natural resources from the Russian Arctic. This resulted in the formal opening of the NSR to non-Soviet vessels on 1 July 1991, only a few months before the U.S.S.R. was dissolved. Russian hopes were high that this new route would attract considerable international shipping, but it was acknowledged that the shipping industry would probably need more information and analysis prior to committing investments and vessels to an unknown expanse and seaway perceived as high risk. Therefore on the initiative of the Soviet Ministry of Merchant Marine contact was made with FNI in 1988, and agreement subsequently reached to establish an international research project covering the NSR. CNIIMF was designated the coordinating institution on the Soviet/Russian side. CNIIMF and FNI produced a pilot study in 1990–1991 which concluded that extensive research was needed, and work continued to develop an appropriate research programme. In 1992 SOF joined the partnership, and in May 1993 the three organizations signed an Agreement for Research Cooperation, together with establishing a Secretariat at FNI for practical coordination.⁴ INSROP was born.

From the start INSROP was intended to be a five-year research programme, conducted in two phases with a review conducted after three years. From early in the process four Sub Programmes were identified,

- Natural conditions and ice navigation,
- Environmental aspects,
- Trade and commercial shipping factors, and
- Political, legal and strategic aspects.

In August 1995, a summer with exceptionally favourable ice conditions, a successful experimental transit voyage was conducted from Yokohama, Japan to Kirkenes, Norway onboard the Russian ice strengthened cargo vessel, *Kandalaksha*, demonstrating the NSR's technical feasibility (Yamaguchi 1996). Results from the experimental voyage as well as results from INSROP's Phase I, 1993–1995, were presented at an academic conference in Tokyo, October 1995 (Kitagawa 1996). In 1996 an independent evaluation of INSROP's Phase I was conducted, and while acknowledging the value of the comprehensive database developed during Phase I and recommending proceeding to a Phase II, the main conclusion was that there was a need to integrate and synthesize the many, diverse and multi-disciplinary results. Therefore Phase II, 1997–1998, consisted chiefly of four parts:

- Smaller projects to cover concrete knowledge gaps identified by the evaluation,
- A simulation project investigating the commercial feasibility of the NSR using historic ice data and various routes, vessel types and tariff models,
- A geographical information system (GIS) of all relevant spatial data collected, created and managed by INSROP (including ice conditions, routes, meteorology, biology and jurisdiction, and an environmental atlas based on these data), and
- An integration project to summarize and integrate all the subsequent results. The latter resulted in Østreng *et al.* (1999a). The final results of INSROP were presented at a NSR User Conference in Oslo, Norway in November 1999 (Ragner 2000). This also marked the end of INSROP.

The findings current to 1999 consistent with the INSROP Sub Programmes with prognoses for each appearing under projections, are summarised below. At the end of the paper appears a section on observations concerning the significance of INSROP.

2. Considerations of the natural environment, ice navigation and ship technology⁵

An integration of research relevant to the natural environment, navigation and operations and icebreaking technology indicated that sea ice covered the length of the NSR in winter with extensive, fast ice prevalent along much of the Russian Arctic coast. The permanent ice extended to the extreme northern points of Severnaya Zemlya and the New Siberian Islands and formed a major obstacle to winter navigation. By the end of the winter, in May, all regions of the NSR, 62–86% by area, were covered by thick, first-year ice. Even during the summer season of minimum extent, ice could be present and could significantly impact vessel traffic. Russian records indicated no NSR region was completely free of ice during summer, and for more than five decades stable, regional ice clusters ('ice massifs'), had been observed and well-documented by specialists in all Russian Arctic coastal seas. The presence of massifs in summer frequently made ice conditions difficult for navigation in three key regions, the north eastern Kara Sea including the Vil'kitskii Strait, the western Laptev Sea, and the East Siberian Sea and Long Strait. These were obstructed by the Severnaya Zemlya massif, the Taymyr massif and the Ayonskii massif.

Russian records were utilised to determine sea ice thicknesses in all NSR regions. Maximum first year thicknesses were observed during April and May, with winter mean thicknesses of 200 centimetre (cm) observed in the eastern Laptev Sea and western regions of the East Siberian Sea. Mean thickness for the south eastern Kara Sea was 134 cm and in the Kara Gates Strait 100 cm. January mean thicknesses for all NSR regions was 150 cm or less. These long-term observations of ice thicknesses provided critical information for the design of commercial icebreaking vessels.

The Russian Arctic with its broad, shallow, continental shelf presented constraints to marine transportation affecting both transit and regional voyages. Southerly routes traversed several shallow straits. Those through the New Siberian Islands were a trouble spot with several shoals of depths of 10 metre (m) in the eastern approach to Dmitrii Laptev Strait and less than 9 m in the Sannikov Strait (Brubaker 2005, p. 12). Information was conflicting with some reports Dmitrii Laptev Strait in the eastern approach limited draughts to not more than 3.3 m and the strait normally was not used by loaded vessels, and others noting the strait navigable with draughts up to 9 m. Least depths of the fairways respectively were approximately 10–11 m and 14 m. Routes north of the islands ran through regions of heavy multi-year ice. The geography of the coastal seas and Siberian rivers favoured development and operation of shallow draught vessels. Due to manoeuvrability and routing through an ice covered strait, consideration was required given to the constraints of shallow water and ice, and frequently along the NSR the route of greatest depth was not accessible due to prevailing ice conditions.

Draught and breadth limitations affected vessel design. If a cargo vessel was to call at intermediate ports, these were limited to 9 m and 30 m, and cargo capacity necessarily would be limited to 20,000 deadweight ton (dwt). For more northerly routes without port calls a maximum draught of 12.5 m and breadth of 30 m could yield a maximum cargo capacity of 50,000 dwt. This ship design model tested during INSROP achieved an icebreaking capability of 1.2 m level ice at three knots (kts). Such potential NSR cargo vessels were approximately one third the size of vessels using the Suez Canal. A breadth of 30 m was utilised as a practical maximum because the *Arktika* class nuclear icebreaker with 28 m breadth was considered likely to remain the primary icebreaker escort until approximately 2019. Future icebreakers and icebreaking cargo vessels would have larger breadths, thereby increasing cargo capacities. However, comprehensive analyses of construction costs and economic feasibility of larger vessels were required. One proposal was to design and operate ice-breaking vessels under the 30 m breadth, and after operational and economic successes were demonstrated, plan larger vessels.

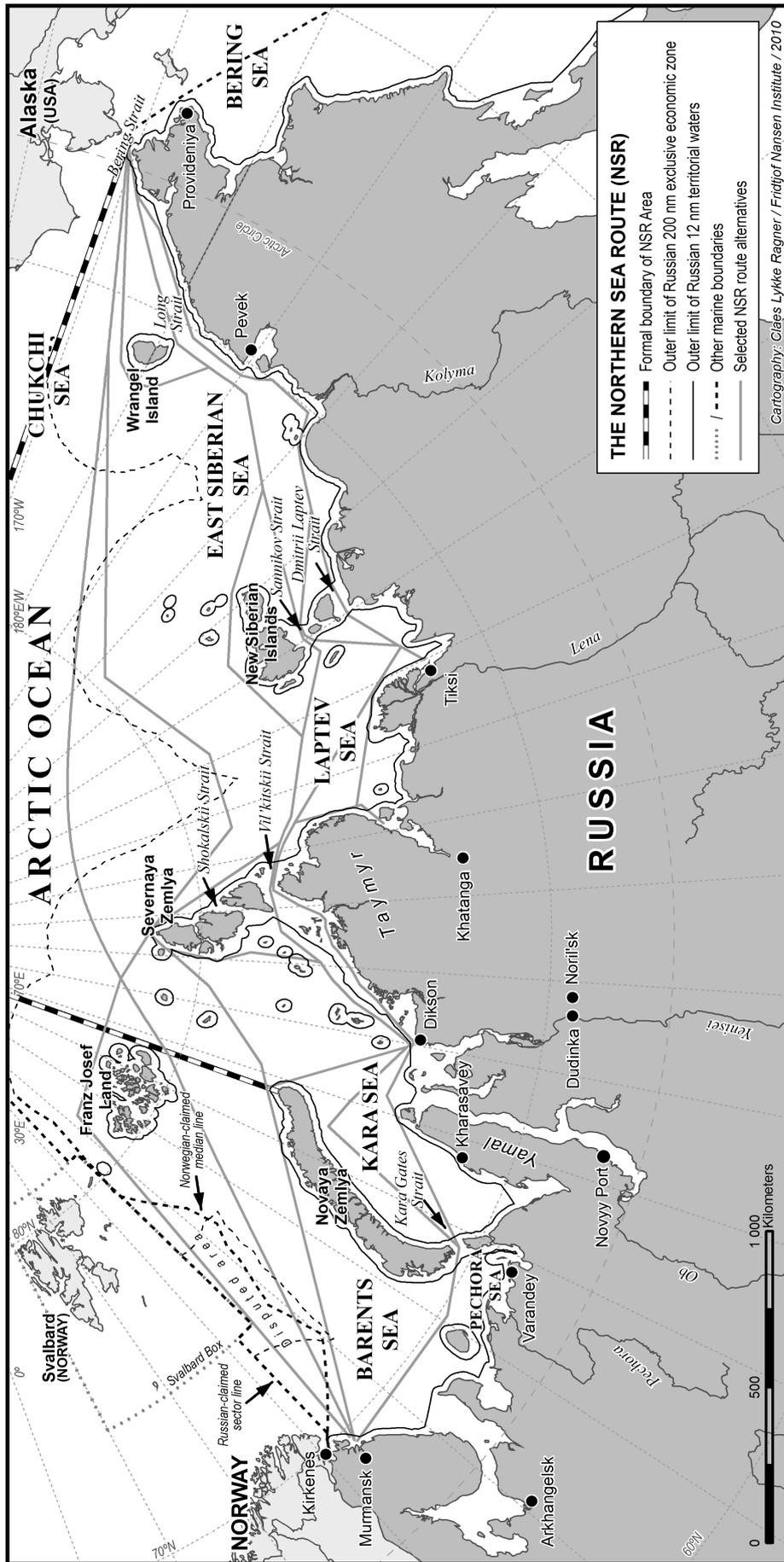


Figure 1. The Northern Sea Route

Two classes of icebreaking cargo ships, the Russian, Finnish built, *Norilsk* SA-15 vessels and the Finnish *Lunni* class tankers were to be standards for future NSR commercial vessels. The tanker *Uikku* in mid-September 1997 made the first transit by a Western merchant ship of the entire NSR. Both ship types were capable of operation without icebreaker escort along some regions of the NSR in summer. Comprehensive assessments of icebreaking capability and hull strength of these two types became available in INSROP, and documentation was also available on SA-15 performance in a wide variety of ice concentrations and snow conditions. SA-15 vessels could operate continuously in .8 m level ice at 5 kts, and when escorted in 2 m ice, the SA-15 vessels could maintain 2 kts astern of the *Arktika* class icebreakers.

The Russian Arctic and Antarctic Research Institute (AARI) maintained an extensive, automatic Arctic ice information system for the NSR, and Russian and non-Russian satellite data were integrated to produce short and long-term ice and meteorological forecasts. The automatic ice classification of satellite synthetic aperture radar (SAR) images including ERS and RADARSAT⁶ was likely to become increasingly routine at ice centres and aboard many vessels.⁷ The Russian National Sea Ice Data Bank maintained by AARI was a valuable resource for forecasting, analysing climatic changes and determining sea ice, as well as planning of the NSR.

Improved sea ice reporting and communications were to continue to assist operations along the NSR. Demonstrations indicated the value of ERS and RADARSAT SAR images transmitted to Russian escort icebreakers. A new SAR receiving station was required in the Russia Arctic so that SAR images including future ENVISAT data as well as future RADARSAT imagery could be received for the entire NSR. Additionally it was necessary to improve coordination of various satellite SAR, visible and microwave images to enhance ice forecasting and ice charts. More commercial communication satellite systems were soon to be available with data transfer capability for digital ice information. In the future vessels could also make use of small, low cost, remotely piloted aircraft carrying video or radar capability, launched and recovered by ship, thus providing additional local or tactical ice information. Other vessel technologies potentially enhancing icebreaking performance and operations included the rotating, Azipod propulsion system⁸ and hull structural standards and improvements that would reduce ice damage. Future escort icebreakers could also include a dual draught design, a single ship designed for effective icebreaking at both 9 m and 11 m, enabling escort both offshore as well into coastal estuaries and gulfs.

Russian historical records of vessel ice damage occurring on the NSR indicated lower class ice vessels operating during the 1970s (and earlier) experienced high rates of damage. For cargo vessels 60–80% of hull damage was substantial on the fore body and 10–20% on mid body. 10–12% of ice damage occurred when cargo ships navigated independently of ice escort, however 50–60% of damage occurred under icebreaker escort.⁹ Most hull damage of all cargo vessels occurred in the East Siberian and Chukchi Seas. These data were influential in efforts to revise the ice classes within the Conference on the Harmonisation of Polar Ship Rules,¹⁰ as well as of key relevance to the insurance industry and the design of future icebreaking vessels.

Icebreaker escort of cargo vessels was required in selected NSR regions during summer and winter navigation and was mandatory with an ice pilot on board in the Vil'kitskii, Dmitrii Laptev, Sannikov and Shokalskii straits, as well as in other areas at the discretion of the NSR Marine Operation Headquarters under § 7.4 of the Rules of Navigation (Rules of Navigation 1996).¹¹ Most new vessel design would therefore have to take into account icebreaker escort as a probable operation. Escort and towing techniques have been perfected by Russian mariners and documented in INSROP; however additional observations were required from cargo vessel captains and other mariners, who have been escorted in a variety of ice conditions. Independent operations of commercial vessels along the NSR were successful during the INSROP period during summer, and

independent icebreaking cargo vessel operations on a year-round basis were technically feasible in the Pechora Sea and the southern Kara Sea, to the Ob and Yenisey Rivers.

Year-round ice navigation was accomplished to Dudinka, on the Yenisei River and port for Noril'sk, since the late 1970s, and it was practicable to increase the capacity of this operation in the south western Kara Sea. Recent regional warming of Eurasia and a reduction in the 1990's of sea ice in the East Siberian Sea could,

'...allow access to the eastern NSR from the Bering Strait to be extended to 150 days...(e)ffective access through the Vil'kitskii Strait may also be increased to 180 days, provided effective icebreaker escort is readily available.'

'Continued warming in Eurasia and throughout most of the Arctic may in compelling ways change this divided picture of the NSR.' (Brigham *et al.* 1999, pp. 119–120).

However, the lack of replacement of Russian icebreakers could become a significant factor in limiting extension of the navigation season due to its required utilisation under the Rules of Navigation. Any future plans for increased shipping along the NSR were to give careful consideration to this critical component.

Observations indicated the *Noril'sk* SA-15 class was capable of 11–13 kts average speed independently operating in summer (July to October). In some regions of the NSR during summer, SA-15 speeds were reduced to 5 kts even under icebreaker escort. During winter (November to June), SA-15 vessels under escort by *Arktika* class icebreakers attained average speeds of 6–8 kts. Simulation research by INSROP on new ship designs provided realistic, estimated average speeds. These involved a 25,000 dwt bulk/container ship, a 40,000 dwt bulk/container ship, and a 50,000 dwt bulk carrier ship, and initial results indicated four to seven kts average speeds in winter (December to May), for all three vessels operating with substantial escort days. For summer (August to October), the first and second vessels showed speeds of nine to 13 kts., the third speeds of 9 to 14 kts. Minimal escort days were required for all three vessels during August to November.

A synthesis of INSROP information on sea ice and past navigation revealed the need for a clear distinction between the western and eastern regions of the NSR. Confining geography, shallow straits, colder regional climates, more severe ice conditions, greater vessel damage and other factors contributed to make the NSR eastwards from the Vil'kitskii Strait a more complicated system.

'The damages observed indicate that the design ice loads specified in the ULA class¹² may apply in the western Arctic, but may be deficient for operations in the eastern Arctic. Much higher design ice loads will have to be adopted for icebreaking cargo ships that operate in the eastern NSR and make transit passage of the entire NSR.' (Brigham *et al.* 1999, p. 108).

Not surprisingly, the length of the navigation season for some years remained fixed at July through October. In contrast were the effective year-round operations in the Barents and Pechora Seas outside the defined NSR, and within the NSR across the Kara Sea to the Yenisei River. Continued warming in Eurasia and throughout most of the Arctic could in compelling ways change this distinction, though this environmental change had yet to influence the periods of access into the Laptev Sea and the Lena River. Feasible vessel transits through the Vil'kitskii Strait and the Sannikov and Dmitrii Laptev Straits remained limited and subject to normally challenging ice conditions.

'Analyses of past climate changes and ice conditions, as well as computer modelling of future scenarios, will be essential to evaluating the future natural conditions for Arctic marine transport along the NSR.' (Brigham *et al.* 1999, p. 116).

Projections of this Sub Programme included, with regards to ice conditions and transit speed, that the simulation analyses indicated the three projected new vessel designs could make an average speed in winter (December to May) of four to seven kts. Previous calculations indicated if the ships could maintain an average speed of 11–13 kts, this would make the NSR for transit voyages economically competitive with the Suez and Panama Canals. In summer the vessels could average nine to 13 kts while the largest could average 9–14 kts. In the early 1980s a Japanese design study was conducted for a 200,000 dwt icebreaking super tanker transporting crude oil from the Arctic to Japan on a year-round basis (Fujita *et al.* 1986). This vessel was designed to operate at five kts in approximately 2 m of ice. The Finnish Masa Yards considered several designs including a 90,000 dwt double acting tanker (DAT) with icebreaking capacity offering the same efficiency as any tanker which could be used throughout the NSR.¹³ Developments in ship designs suggested speeds approaching what would be required to bring the NSR into competition with the Suez and Panama Canals.

With respect to vessel designs, depth conditions, cargo ships and the icebreaker fleet, to improve on and eventually overcome the ice and depth limitations, two options were available. These involved intensified dredging to achieve better depth conditions, or building larger vessels than those anticipated under INSROP with draughts adapted to existing depths. The Japanese Ship Research Institute in Tokyo conducted trials applying available technology to model an icebreaking oil tanker of 200,000 dwt, possessing a cargo capacity of 246,000 cubic m with a draught of 20 m (Fujita *et al.*, 1986) corresponding to depth conditions in the Bering Strait, which was possible to build with a draught of 11 m (H. Kitagawa, personal communication, 21 Apr 1991). This model vessel was tested to have a breadth at the waterline of 52 m as opposed to the 30 m used as maximum in the above simulation studies. This example provided more promising prospects than those previously shown during INSROP. The end result could be promising regarding innovative engineering when it came to producing a shipbuilding technology capable of overcoming many NSR challenges. Statistics indicated damages to vessels caused by ice were more serious and frequent in the eastern NSR than in the west. This implied the investment costs for new vessels assigned to missions restricted to the western Arctic might be lower less than those in the eastern Arctic. Ships built for transit operations would have to comply with the ice load measures of the eastern Arctic. By differentiation in ice load designs investments could be reduced, compared to requirements for all ships to meet the highest ice loads of the NSR. If however this strategy was implemented and pursued with the aim of cutting investment costs, an element of inflexibility would also be introduced as vessels designed for west Arctic operations could not be used outside of the region.

Concerning operating seasons and ice conditions, apart from improvements in shipbuilding technology and associated navigational systems, the regional warming of Eurasia seeming to have manifested itself in the 1990's could be of assistance. The warmest water temperatures recorded on the eastern Bering Sea shelf occurred during the summer of 1997,¹⁴ and if the sea ice reduction were in fact caused by global warming which scientifically could not be excluded albeit not yet confirmed,¹⁵ navigational conditions in the eastern NSR could improve further. At the same time improvements in vessel designs and associated activities represented the safe course of action for extending the sailing season. The greenhouse effect first and foremost was a catastrophe to be counteracted if possible by the means available. If global warming proved to be a phenomenon affecting the Arctic, it would continue to melt sea ice reducing its extension, and thus could act as a supplementary phenomenon supporting Russian endeavours to extend the navigation season.

3. Environmental Considerations¹⁶

From the start the aim of INSROP was to develop a basis for environmental assessments with regard to activity on the NSR. Faced with the transitional state of Russian environmental

management strategies during the 1990s a need was recognised early for a flexible approach. One off solutions were to be avoided, and reuse of the findings was to be emphasised. Efforts focused on two main components: a systems environmental information base characterising the environment in which the marine navigation occurs – the baseline data in the *Dynamic Environmental Atlas* (Brude *et al.* 1998); and tailored methods and procedures for damage analyses and a systematic process for implementation.

The latter included a stepwise approach to the selection of significant natural resources, identification of relevant impact factors of the activity, and indication of likely interactions by simple and robust assessments. The integration of these two through the *NSR Environmental Assessment & Planning System* made the *INSROP Environment Assessment* complementary to the basic elements in the *Strategic Environmental Assessment*. The results of the study, the baseline of the temporal and spatial distribution of vulnerable natural resources, an integrated information system, and methods for impact analyses, provided a basis for environmental assessment relevant to NSR activities in the short term. They similarly provided a basis for long-term assessments of future developments. The procedures were easily implemented for specific case studies, such as assessments of sailing routes, oil spill risk and contingency planning, and had the transparency and stringency important to such processes. If new findings deviated significantly from the initial assessment basis, whether in terms of changes in the baseline, vulnerability or environmental threats, the flexibility of the information technology (IT) system enabled online adjustment of any individual parameter. The adjusted datasets could subsequently provide updated input to damage estimates, mitigating measures or monitoring strategies. This concept was accepted among scientific communities in Russia and Norway and proved to be consistent with Russian regulations governing preliminary environmental impact assessment (EIA).

The main components of the system were selected as cost effective solutions to implement current computing technology. INSROP GIS was developed as an ArcView application for use on personal computers (PC) running Microsoft Windows.¹⁷ ArcInfo running on UNIX work station was used to prepare the datasets for use by ArcView and to run analyses beyond the capabilities of ArcView on a normal PC.¹⁸ These were widely used by the GIS community providing the necessary IT tools for handling large volumes of environmental data and developing applications for a wide variety of analytical purposes. The selected software also provided a standardised system for linking textual, tabular and graphic information to digital maps, which facilitated export and import of geo referenced data in formats compatible with the major GIS on the market.

Since the ultimate objective of an EIA was to indicate the most likely consequences of an action, in this case NSR marine activity, the challenge was to harmonise the assessment retrospectively as well as to enable future predictions. Environmental impacts were therefore to be assessed through the different levels of NSR activity. Consequently, the status of the NSR environment was a function of past NSR activities, as well as from other factors with a significant influence on the NSR environment. Various factors were within the Arctic, others not. The basis for such comparisons however was vague. The resolution of the baseline data was in most cases inappropriate for identification of temporal and spatial trends in key bio- chemical parameters, including contaminant levels and population trends. The comparison of sources and their importance in terms of weighting the load from NSR activities versus other loads, within or outside the Arctic, could not be determined quantitatively by scientific means.

Overall conclusions were drawn on this basis, combined with an awareness of the inherent attributes of the environment and of NSR activities. This summarized what was known of the temporal and spatial distribution of the selected valued ecosystem components (VEC's), their ecological dynamics and vulnerability to the given species specific impact factors (Moe and Semanov 1999, pp. 178–185). Conclusions included the following.

First with the exception of local terrestrial, river, harbour and port pollution, and earlier dumping of radioactive waste from the icebreaker fleet, as well as waste and wreckage accumulation, there was not scientific evidence civilian navigation as such had resulted in significant stress to the NSR environment. Navigation along the NSR had continued for decades. Even though significant local contamination of ports and harbours, accumulation of waste and garbage on the shore and local areas had been documented, there was no evidence that the large scale trends of several declining ecosystem populations had been directly caused by marine navigation.

Second, increased frequency of navigation would however inevitably increase the risk of ship accidents, thereby increasing the risk of accidental release of oil. Large scale oil spills could have deleterious impacts on the marine environment. The most vulnerable period was assumed to be during the most productive season (late spring to summer) which also corresponds to the most frequent navigational period. During this time vulnerable natural resources were spread widely over the NSR region. On a spatial scale particular attention was to be given to the protected areas, including the Lena Reserve which had been expanded to include the New Siberian Islands.

From an environmental viewpoint there was also an obvious link between commercial shipping on the NSR via the port, harbour and loading facilities to land based development of industry and infrastructure. These activities have been shown to cause deleterious effects in regions of the limnic (marshy lakes) and the terrestrial environment of the Russian Arctic as elsewhere in the Arctic. Plans for offshore hydrocarbon development reflected the introduction of new impact factors in the NSR region, as these were activities causing chronic marine discharges and air emissions. Regular discharges from offshore petroleum extraction in the North Sea have been shown to affect the benthic (bottom) communities as well as fish resources in the vicinity of installations. Petroleum activities necessarily contributed significantly to increasing the risk of accidental oil spills.

The Arctic environment was currently exposed to contaminants and stress in a variety of modes, and it was the cumulative effect, the sum of the stress from every individual source, that provided the overall impact and significance to the environment. This also included impact factors and loads not assessed in detail within the *INSROP Environmental Impact Assessment*, including persistent organic pollutants¹⁹ (POP's) which had been a focal item of the Arctic Monitoring and Assessment Programme (AMAP) under the Arctic Council. Arctic pollution was definitely of growing concern among official bodies and the scientific community. The trend towards more frequent low level environment deviations was gradually reducing the common perception of the Arctic as a pristine environment, and increased development of the NSR would involve additional factors that cannot help but contribute to this load. Particularly important points included the following:

Physical disturbances were generated by shipping operations, dredging of harbours and land based developments such as hydrocarbon production. The latter was known to cause habitat fragmentation and physical barriers which indirectly affected the reindeer herding of indigenous peoples.

Release of contaminants such as radio nuclides from nuclear waste; petroleum hydrocarbons from extraction and transport of oil and gas; and POP's from power stations, mining industry and landfills; were considered among the most pronounced threats to the environment along the NSR. The marine, limnic and terrestrial environment could be expected to suffer significantly from such releases.

Accidental oil spills could cause the most serious effects. Should these occur at the wrong place at the wrong time, for example at the ice edge, in polynyas,²⁰ during the time of high productivity, the impacts could be serious. Shallow waters were the most sensitive to such pollution, and these areas were important to organisms of all levels of the Arctic food chain. Adverse effects could easily pass

from one level to another ultimately affecting the entire regional ecosystem. The limnic and terrestrial environments had proved to be equally sensitive. The impact could last for decades because the Arctic environment was so slow in recovering.

Chronic, long term, low level pollution could affect all ecosystem levels within a given area. It was the low dose and long term exposure that represented the most serious threat to the environment, and the Arctic was no exception. In the marine environment the shallow waters of harbours, ports and loading facilities were expected to suffer the greatest impact. However it did not seem likely offshore water organisms would maintain a state of chronic stress generated by regular, low level oil discharges from shipping operations. The limnic and terrestrial environments had been shown to have been subjected to many small oil spills and leakages from land based petroleum developments. Significant impact was widespread in western Siberia. Unless predominant, developmental strategies were changed dramatically, similar patterns could be foreseen in new developmental regions as well.

Interaction between man made noise and the environment could be temporary or chronic. Temporary noise was considered of less importance unless it occurred at the wrong place at the wrong time, for example near bird cliffs. Exposure to chronic noises could result in higher trophic level²¹ organisms such as birds and mammals abandoning their habitat, but habituation (acclimatising) would also occur. If important habitats or home ranges were permanently lost, population damage was not unlikely.

Finally, *accumulation of contaminants* was facilitated by the ability of many Arctic organisms to withstand food shortage by storing energy as body fat when food was unavailable. Ultimately such contaminated bio accumulations could reach the indigenous and local peoples if the natural resources within their main area of residence as well as subsistence branches were affected (Moe and Semanov 1999, pp. 146–147, 155, 169 and 204–205). These in addition to other activities that could be harmful to the linkage between the environment and local people needed to be assessed in detail prior to implementation of NSR activities. In this respect the *Dynamic Environmental Atlas* was to be considered a central source.

Generally, environmental damage in the Arctic could prove longer lasting than in temperate regions. The transfer of damage in the food chain was facilitated, and such damage was a function of the fate of the impact factor, the resources at risk and their ecological attributes. Consequently, the vulnerability of the Arctic organisms would vary from species to species, as well as between time periods and various geographical regions.

Projections included that, despite these warnings and exceptions noted, there was insufficient scientific evidence that civilian navigation had resulted in significant stress to the NSR environment. Arctic development therefore was offered an opportunity to plan for environmental concerns in advance and thus avoid much of the devastating and unnecessary impacts accompanying human activities elsewhere. Among measures to accomplish this goal were the following.

NSR Environmental Assessment & Planning System could be used for environmental screening and *Preliminary Environmental Impact Assessments* to be used when considering developments. Recommendations from the World Bank's checklist on mitigating measures for the most relevant activities and developments on the NSR were to be considered in new projects (Moe and Semanov 1999)²². Nature conservation areas were to be avoided to preserve quality, representativeness and the biodiversity of nature. Vessel traffic management systems were to be carefully considered for ports, and loading facilities constructed or reconstructed for sea borne oil transportation. Port fees were to be considered reduced, without discrimination, to any vessel owner proving measures

emphasising increasing safety and providing training to crews improving their technical merit and quality. The use of anti fouling paint containing organotin compounds was to be prohibited. Vessels in transcontinental navigation were to comply with and Russia to enforce all IMO Guidelines, including that for preventing the introduction of unwanted aquatic organisms. Radioactive pollution was to be monitored in conformity with the international conventions, and programmes dealing with nuclear power generation, processing and waste disposal made effectual.

4. Economic Considerations²³

The chief purpose was to examine the economic viability of the NSR and indicate future challenges. However, in the decade since international commercial navigation was permitted through the NSR, trade flows in the Russian Arctic had remained at best static and had fallen short of expectations. At the same time considering the economic and social turmoil in Russia following the break up of the Soviet Union, this was not surprising.

In spite of the slow start and rather disappointing performance there still existed support for considering a 'future potential' for the region as an origin of exports, a destination for imports and a transport corridor between West and East. For the development of a future origin of exports and designation for imports however it was essential for the Russian government to include the NSR in the future expansion plans for its extractive industries. Since Russian regions bordering the NSR were rich in mineral raw materials, particularly energy resources, whether such areas such as the Yamal Peninsula would receive enough financial backing to develop into mineral resource exporters remained an open question. Either way such decision would have a profound effect on any further development along the NSR.

The NSR had been used for small amounts of exports of dry bulk commodities and imports of supplies to the local populations. Trans-Arctic trade had been of rather minor commercial significance, although important for observations to improve knowledge of ice navigation. INSROP studies chiefly indicated both the technical and economic feasibility of energy exports along the NSR to the West. Liquefied natural gas (LNG) was a favorite, however other methods explored included: marine transport of natural gas hydrates in dry bulk form, liquefied petroleum gas exports, and crude oil exports.

Such trade flows however could occur only after the necessary investments allowing exploitation and production of such resources. The initiative rested much in the hands of the Russian State, particularly its large energy trading monopolies. The future of the NSR would only have a solid foundation when a policy governing the destiny of the NSR had been decided, the required domestic or foreign financial resources found and the infrastructure set in place.

'The resources are there, the technology is available, but the remoteness and extremities of the NSR can only be tackled by a State that is ready to understand and support strategic projects. For the Russian State to be able to do so will require considerable time and effort until the economy can emerge strong from its currently turbulent transition phase.' (Tamvakis *et al.*, 1999, p. 279)

The marine insurance issue remained dormant in INSROP. There was little indication the shipping companies were considering using the NSR, particularly for high value vessels. Such vessels were generally not constructed for navigation in ice. Additionally the shipping industry had yet to make its own analyses of the actual economic advantages involved. Although limited low value, bulk cargo operations could be considered, it was unlikely even such operations would take place on a year-round basis. However, marine insurers are innovative and responsive to the demands and requirements of the shipping industry, and in that respect NSR risks would be treated no differently.

Marine insurers required their own studies responding to the specific needs and demands of underwriters while accessing the special risks in navigating Arctic waters. If shipping companies were interested in using the NSR, insurers would provide the necessary risk cover.

What could thus be accomplished? There were enough private interests outside Russia that could invest in projects along the NSR. It became evident, however, that as a minimum, a reliable and stable political and legislative framework was necessary for such initiatives to evolve. In addition a reliable, operational environment was absolutely essential for the NSR to achieve viability as a transport corridor. These same conditions were elementary prerequisites for success in any transit operations. Results were to be interpreted in a time related context. Any conclusions for the NSR which could be valid for the short to medium term, two to ten years, would not necessarily hold for the longer-term. Nor would points viewed negatively be necessarily impediments for future prospects. The qualifications indicated could be treated as opportunities to be taken advantage of in the right time. It was possible the NSR would never compete on par with warmer sea routes, however, given the right conditions it could provide a shrewd investor with considerable profit making opportunities.

Projections included first the necessity for the Russian government to include the NSR in plans for its extractive industries, on land and on the shelf. This underscores the significant relationship between of the land and sea for increasing use of the NSR. Historically, it was economics that stimulated activities for use of the NSR to transport resources extracted on land. This included sable and other furs. Second, there were several commodities that appeared well suited for creating a sustainable cargo flow. Ferrous metals were expected to continue to be successfully exported to Asian Pacific States, and an estimated 1.7–1.9 million tons could possibly be carried through the NSR. A further flow of 0.5 million tons could be created by fertilisers also exported to the Asian Pacific States. Timber products could account for an additional 1.3–1.7 million tons, and smaller flows of apatites from Khatanga could be transported to foreign markets. From this an estimate of annual total of 3.5–4.1 million tons of cargo could be available for transport during the period 2005–2010. This was excluding hydrocarbons that would become dominant in the future. In a short and medium term of two to ten years, trans-Arctic trade on the NSR seemed likely to increase substantially from its present level; however, its share of world trade would remain insignificant. Third, the necessary investments, domestic and foreign, would have to be provided for. Only when a policy concerning utilisation of the NSR had been found and the infrastructure in place, would the future of the NSR have a solid foundation. Fourth, as had also been historically demonstrated, there was a need for foreign involvement not least in times of national crises to further develop the NSR. Given the state of the Russian economy foreign investments would seem a prerequisite. Fifth there was a pressing need for a Russian State actively involved in regional development. This initiative was the responsibility of the Russian government and its large energy trading monopolies. Though the natural resources were there and the technology available, the remoteness and extremities could only be managed by a State ready to understand and support strategic projects. The Russian Federation pooling resources with regional authorities would need to establish NSR operational efficiency to attract new users. As was the case during the Soviet period a strong and active State was needed that could assume leadership in NSR developments.

A major conclusion concerning marine insurance was that the international insurance market would be willing and able to underwrite NSR risks. However, the data assembled under INSROP required further development. The International Underwriting Association (IUA), representing almost all aspects of marine insurance interests, required specific studies undertaken by the world's premier casualty surveying group, the Salvage Association.²⁴ This would respond to the specific requirements of underwriters while taking account of the special risks involved in navigating Arctic waters. Nevertheless, there was no question if the shipping industry wanted to use the NSR, insurers would cover the necessary risks.

5. Military, Political, Legal and Indigenous Considerations²⁵

From an objective, operational viewpoint military considerations were no longer dominant obstacles to civil utilisation of the NSR. Indeed, the reverse could well apply in that military interests were being subordinated to economic needs. However, the discord perceived between, and within, the Russian sectors governing the security implications of opening the NSR to international usage, created in other States a high degree of uncertainty about the state of affairs. In this respect subjective views of a political situation which was unstable, chaotic, uncertain and possibly dangerous would be more important in influencing Western decisions than military realities. If the political turmoil was not reduced or brought to a halt, the likelihood of involving non-Russian nationalities in NSR operations would be small in the short and medium term. Here as in most other respects objective realities counted, while subjective perceptions, right or wrong, decided. In the NSR management system that emerged after 1991 three principal actors played a role: the Federal Government, regional governments and commercial interests. The structure was still in the making; the momentum of change was basically to be found in the tug of war between the centre and periphery and not in the competition perceived between the sectors. The first order of priority for the Federal Government was to avoid becoming a failed State, which could lead to a long stagnation and drift in which no one really ruled.

Legal issues surfaced from a comparison between the comprehensive Russian Arctic legislation and enforcement and the 1982 Law of the Sea Convention (LOSC), Article 234 for ice-covered areas which encompassed various key terms. These included: mandatory notification and authorisation, possible application on the high seas, five forms of leading in ice, fees, liability, discharge and safety standards, reporting, inspection if deemed necessary, stopping, detention and arrest, suspension if deemed necessary, removal for violations, criminal liability, design, equipment, manning and construction standards, special areas, and, application to State vessels. Due to the inherently vague formulation of LOSC Article 234, other than for six elements (noted below), it would be difficult to maintain that the unilaterally adopted Russian provisions exceeded intended limits. Russian practice of its regime found support not only from Canadian Arctic practice, but also from that of the U.S. as an Arctic coastal State with regards to Alaska. All three States in addition participated in Arctic environmental cooperation and coordination including the Arctic Council at the diplomatic level and the Conference on the Harmonisation of Polar Ship Rules at the ministry or agency level.

These differing six elements were geographic application including the high seas, application to State vessels, mandatory fees, icebreaker assisted pilotage, icebreaker leading and special areas. The weakest point was the attempt by Russia to claim, however vaguely, the provisions were applicable on the high seas outside the 200 nm. exclusive economic zone. This had no support either from Arctic practice or from conventional or customary international law. Also very weak was the Russian claim of application of its regime governing all vessels including State vessels. Although supported by Canadian practice, this was contrary to U.S. practice and enjoyed no support under international conventional and customary law. Weak, but less so, was the Russian requirement for fees for passage along the NSR. Though acceptable as payment for specific services rendered for passage through the territorial sea, and possibly acceptable under Article 234 as scientifically sound for environmental protection, such charges were required to be non-discriminatory and in payment for specific services rendered. Russian provisions were probably discriminatory in fact as well as blanket, required solely for entry and when little or no services were rendered. Russian requirements for icebreaker assisted pilotage, icebreaker leading and closed special areas stood stronger. If compared to the U.S. practice, these were arguably in excess; they were however more consistent with Canadian practice. Additionally, even though these requirements were not exactly the same as the Canadian, they could plausibly be argued to be justified as part of a sound

environmental protection policy required under Article 234, having 'due regard to navigation and the protection and preservation of the marine environment.'

Looking at navigational practice, it was the U.S. as a maritime power which had most consistently opposed the Russian Arctic regime through official declarations and submarine passages. Actual submarine voyages were only vaguely substantiated. U.S. declarations have followed traditional law of the sea positions taken by maritime powers including that of the international straits regime. Little was forwarded by the U.S. clarifying the relation between the Article 234 and the international straits regimes. With the exception of the Vil'kitskii Straits incidents in the mid 1960's involving U.S. Coast Guard and Navy vessels in the Laptev, East Siberian and Kara Seas²⁶ and the Norwegian *Sverdrup II* in the Kara Sea in the mid 1990's, all surface voyages appear to have been made in substantial compliance with the Soviet/Russian regime. The Norwegian State vessel, *Sverdrup II*, conducted several voyages in 1995 and 1996 in the Kara Sea, which resulted later in a formal protest by the Russian Foreign Ministry to the Norwegian Foreign Ministry. No other States have been found clearly opposing the Russian regime. Since unequivocal Soviet or Russian protests were delivered in connection with both the U.S. and the Norwegian incidents, it could be assumed some indication would likely have been given should other similar events have occurred. So far of the known commercial vessels of Finnish, Latvian and German flag, all were apparently navigating in compliance with Russian provisions.

A conclusion could thus be drawn that a broad interpretation of Article 234 was being practised through substantial State compliance with and support for the Russian provisions for surface traffic for both commercial (and State vessels). The practice included all the key items noted except application to State vessels, application on the high seas and mandatory fees. The U.S. declarations and voyages, and Norwegian voyages were to preserve traditional positions under conventional and customary international law, of the international straits regime and freedom of passage of State vessels subject to innocent passage in the territorial sea. Should utilisation of the NSR become economically feasible, particularly the discriminatory and blanket Russian fees could come under scrutiny with respect to U.S. vessels. Should this compliance continue, it would be difficult to argue that customary international law was not being formed for the Arctic Ocean. There continued to be few other interested States. The legal results of occasional foreign submarine passages held secret by all States were indecisive. The passage of submarines also earlier had been an aberration in law of the sea, concerning requirements for surface passage in the territorial sea including international straits. It could therefore be argued this continued abnormality would not hinder the formation of customary law in the Arctic.

Viewing the Russian Arctic indigenous peoples, the NSR was part of a transport complex central in solving a pressing social problem ~ the supply of northern populations with fuel, provisions and consumer goods. This was the main possible effect a commercial opening of the NSR would have on northern Russia. An opening of the NSR could also permit increased industrial activities and cause further improvement and development of the already existing river and road transportation system covering the areas inhabited by the indigenous groups. Improved access could facilitate development of a regular tourist industry which could improve access to markets and distribution networks for native products. Revitalisation of the economy could reduce poaching, thereby decreasing tension between the urban and the rural populations. An increase in goods transport could help to subsidise such transport to additional remote areas.

However, these possible positive effects could have just as many negative consequences. The NSR and its industrial customers were primarily non indigenous peoples with little interest or financial ability, without direct government subsidies, to provide the service and goods required in the villages. Developments would occur in areas bordering NSR industry and trade activities. Indigenous communities farther away would have to be content with traditional industries while

grants and public amenities would decline. In the event of competition between new industries and more traditional economies, industrial preferences would be likely to dominate. Dangers connected with the opening of the NSR included: contributing to the sometimes serious alcohol problems suffered by indigenous peoples; and, the increased risk for the release of hazardous substances particularly in the Bering, Chukchi and Barents Seas as well as litter into the sea waters, coastline and delta areas. Further threats included shipping accidents with long-term effects on indigenous subsistence, including reduction of productivity and revenues from hunting of sea mammals and fishing; and, illegal fishing. Threats also included: increased industrial activities with risks of continued and increasing pollution; erosion and reduction of pastures and grazing areas; barriers to migrations of domestic and wild reindeer both on land and over river ice; and, changed migration patterns of whale and other marine mammals threatening indigenous sources of stable food as well as social relationships. More effort needed to be invested in terms of time and funding to organise and conduct further research covering the probable impacts of NSR related activities on indigenous clusters and livelihoods. The extent of the area and the heterogeneity of the indigenous communities embraced by the NSR were of such scope that it was not possible in a short time to chart completely all the cultural effects and impacts of increased navigation.

At least two precautionary steps could be taken, new or extended legislation with considerable respect for indigenous land use and an effective enforcement and implementation of environmental regulations. Most important of all was the need for the indigenous societies to be included as part of the process of creating the framework for NSR development, and their premises to be viewed and treated on an equal basis.

‘Hot spots’ were found to be aggregated along the NSR including clusters of societal and natural values or interests that needed serious consideration in terms of sustainability.²⁷ To preserve the socio-biodiversity in these sites two pre-conditions needed fulfilling. All the individual values or interests clustering needed to be seen as equally worthy of preservation. Even if some of the parameters would be more negatively affected than others by navigation, the ultimate goal needed to be that none were harmed beyond repair and reestablishment. Additionally, the first pre-condition called for a new kind of navigation, multi-value navigation as opposed to single-value navigation. The former addressed both the economics involved in navigation and the sustainability of the socio-biodiversity of the sites, while the latter basically focused on meeting economic objectives. Any attempts to apply a 19th century ‘Klondike approach’ to economic utilisation would likely fail and be reported to the outside world by watchdog, partisan organisations. A new breed of ice captains and crews were needed to meet the requirements of modern Arctic multi-value navigation.

Projections of the security aspects indicated that the NSR lacked strategic, operational utility and consequently, military importance. Military strategic interests could not be evoked as a valid and reliable impediment to increasing civilian and international use of the NSR. The hegemonic features of the Cold War were history and could no longer be allowed to blur reality and produce false perceptions. The NSR held a civilian, not a military potential.

Concerning international legal aspects it was expected that with the exception for application on the high seas, the U.S. would require commercial vessels under U.S. flag to follow the Russian regime including fees, if not discriminatory, and particularly if for services rendered. This was based upon the U.S. practice in the Canadian Arctic characterised by compliance by U.S. commercial vessels with the Canadian regime, as well as U.S. State Department declarations, U.S. participation in the Arctic Council and the Conference on the Harmonisation of Polar Ship Rules, and U.S. domestic legislation, all implementing Article 234 to a degree. The U.S. would continue to uphold its objections as it had since the mid 1960s to the Russian provisions related to the sovereign immunity of State vessels and application of the international straits regime under conventional and customary international law. NSR impediments if recognised would encompass global, strategic implications

impeding naval mobility including in straits of strategic importance to the U.S. In the Arctic including Russian waters the U.S. presumably navigated its submarines occasionally, chiefly in accordance with traditional law of the sea. Non-clarification by the U.S. of the relation between the Article 234 and the international straits regimes would likely continue as it had since the negotiation of the former in the mid 1970s. With respect to commercial vessels other States would likely follow suit, since it was only the U.S. and Norway that protested the Russian provisions. Bilateral relations would be little affected with either the U.S. or Russia, particularly if other State vessels did not navigate these waters.

With respect to indigenous cultures at this first investigative stage positive effects of the NSR included supplying northern populations with fuel, provisions and consumer goods, however, NSR developments could have numerous negative consequences affecting indigenous economies and in various case health and social relationships. Precautionary corrective steps included new or extended legislation exhibiting respect for indigenous land use and effective enforcement and implementation of environmental regulations. Especially indigenous societies needed to be included in creating NSR developmental frameworks, and their premises to be viewed and treated equally.

Finally, concerning hot spots particular interest groups formed and acted on the perception that interests of value to humankind were being disregarded or neglected in public decision making. Most issue areas had advocacy organisations to present their case, and the combination of a thoroughly organised globe and the IT revolution brought even the most remote locations into the limelight. The world was becoming increasingly transparent, and misdeeds perceived in management of esteemed values would be broadcast to a worldwide public. Given the vulnerability of the Arctic ecosystems and the external pressure put on the survivability of indigenous cultures, there was every likelihood the value of sustaining the socio-biodiversity of the NSR would be addressed by partisan organisations already involved in cultural and environmental affairs. Multi-value navigation could prove a constructive, and inexpensive measure, having some bearing on influencing such organisations to rest their case or moderate their actions.

6. Significance of INSROP – Observations

6.1 Administration of INSROP

Creating and carrying out INSROP was a challenge from inception to end with administration. It took years of networking, negotiations and lobbying to shape the programme and to obtain funding, and its eventual initiation was a witness to the strong wills and personalities of the key figures involved. Daily cooperation and coordination also met challenges, and it was often difficult to bridge language and cultural gaps between the three principal partners, the Japanese, Norwegians and Russians. These three often held different priorities and were from countries with varying business practices. One important early issue which sparked marked disagreement was whether to focus the programme solely on the straightforward, key issues of natural conditions, navigation and economics, or to also include possibly more complex and controversial topics such as the environmental, military, political, legal and socio-economic aspects. In the end the latter view prevailed, and this probably provided INSROP's results with increased legitimacy and wider acceptance. On the other hand, this also in part led the main Japanese sponsor to establish the Japanese Northern Sea Route Programme (JANSROP), focusing mainly on aspects of technology and natural science, which operated parallel to, but independent of, INSROP. A great deal of 'diplomatic' considerations were required to uphold the trilateral balance, and in some cases this resulted in a less than ideal distribution of projects and funds, along with a certain inflexibility in adjusting research priorities. In spite of this the sheer quantity and diversity of results, and not least

the continued relevance ten years on, indicate on the whole that the complicated organisation worked well.

6.2 *INSROP Sub Programmes*

With respect to the Natural Environment, Ice Navigation and Ship Technology Sub- Programme, statistics of vessel damage are vital for naval architects and ship classification societies. Up until this day, there has, however, never been published reliable data of damage to Russian vessels navigating the NSR. From this analysis could be made on the cause and effect of the damages, and from this establish safer vessel design (Kitagawa, 2008a). Additional research could as well have been carried out, although probably difficult to achieve, covering political developments within Russia that affected the opening of the NSR, under the Military, Political, Legal and Indigenous Considerations Sub Programme. This also likely would have included ramifications for the Economic Considerations Sub Programme. Similarly, due to the expansiveness of the Russian Arctic and little voice the numerous Russian Arctic indigenous groups enjoyed, more research could have been conducted on the expected consequences opening of the NSR would play for these indigenous peoples including additional precautionary measures. This would likely have included also ramifications for the Environmental Considerations Sub Programme.

6.3 *Overall Results*

Overall, the results of INSROP might be said to have been somewhat discouraging for the international shipping industry. Even though it was demonstrated that navigation along the NSR was technically feasible and that there was a cargo base for export, import and conceivably transit, it became obvious there were challenges involved for the NSR to become a commercially viable option in the short or medium term. It could be viewed as somewhat ironic that INSROP probably due to its rather complicated and inflexible organizational structure failed to adapt underway and include research on the one factor that could eventually enable large scale shipping, climate change and its effects on ice conditions. At the same time it was only in the few years subsequent to the conclusion of INSROP did researchers generally become aware of the significance of the changes taking place (K.A. Moe, personal communication, 6 Mar 2008). A wealth of new and unique knowledge on the Russian Arctic was produced and made available to the international community, much information that was previously only known internally in Russia. This is information and results that are still being sought and utilised today, ten years later. INSROP also pioneered cooperation between Russian and foreign scientists in Arctic fields, networks that endured. Arctic 'sophistication' was increased, both East and West were educated in dealing with one another, and data acquisition and analysis were carried out, along with the corresponding development of personnel. This allowed a secure basis to be developed allowing further Arctic multi-disciplinary studies to be accomplished. Following the end of INSROP interest in the NSR subsided for some years, but as awareness increased of the realities of climate change and its effect on the Arctic ice, a rise occurred in interest and demand for INSROP's results from the shipping industry, the authorities and the media. A number of new projects has been initiated. Therefore, while INSROP could be argued to have been premature, the knowledge it produced could become more relevant, and perhaps there exists a greater potential for its practical utilisation in the future.

Acknowledgements

The authors would like to express their appreciation to Professor Edgar Gold, Professor Hiromitsu Kitagawa and Environmental Consultant Kjell A. Moe, participants in INSROP from the start, for their contributions.

References

- Adamson, L. (ladamson@imo.org), 4 December 2009, RE: Revised Guidelines for ships operating in Arctic and Antarctic Ice-covered Waters (Polar Guidelines). Email to D. Brubaker (douglas.brubaker@fni.no).
- Brigham, L.W., Grishchenko, V.D. and Kamesaki, K., 1999. The Natural Environment, Ice Navigation and Ship Technology. In: W. Østreng et.al. eds. *The Natural and Societal Challenges of the Northern Sea Route – A Reference Work*. Dordrecht, The Netherlands: Kluwer Academic Publishers, 47–120.
- Brubaker, R.D., 2005. *The Russian Arctic Straits*. Leiden, The Netherlands: Martinus Nijhoff Publishers.
- Brude, O.W., Moe, K.A., Bakken, V., Hansson, R., Larsen, L.H., Løvås, S.M., Thomassen, J., and Wiig, Ø., 2008. Northern Sea Route Dynamic Environmental Atlas. *INSROP Working Paper*, 99. Lysaker, Norway: Fridtjof Nansen Institute.
- Fujita, Y., Narita, Y., and Kitagawa, H., 1986. Design study of a 200, 000 dwt Icebreaking tanker. In: *Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering Symposium, 1986*. New York: American Society of Mechanical Engineers, 192–199.
- Gold, E. (edgold@bigpond.net.au), 29 March 2008, RE: Working Paper. Email to D. Brubaker (douglas.brubaker@fni.no).
- IACS, 2007. *Requirements concerning Polar Class*, IACS Req. 2007. London: International Association of Classification Societies. Available from: http://www.iacs.org.uk/document/public/Publications/Unified_requirements/PDF/UR_I_pdf410.pdf. [Accessed 11 January 2010].
- IMO, 2002. *Guidelines for Ships Operating in Arctic Ice-Covered Waters*. IMO Doc. MSC/Circ.1056 and MEPC/Circ.399, 23 December 2002. London: International Maritime Organization.
- IMO, 2009. *Guidelines for Ships Operating in Polar Waters*. IMO Resolution A.1021(26), 2 December 2009. London: International Maritime Organization. (Adamson 2009). Also listed as Resolution A.1024(26). Citation available from http://www.imo.org/includes/blastDataOnly.asp/data_id=26999/INF-10-Rev-1.pdf. [Accessed 11 January 2010].
- INSROP Secretariat, 1993. *INSROP Newsletter*, 1 (1). Lysaker, Norway: Fridtjof Nansen Institute.
- INSROP Secretariat, 1999. *INSROP Programme Report 1993–1998, Summary and Statistics of all INSROP Products and Activities*. Lysaker, Norway: Fridtjof Nansen Institute.
- Juurmaa, K., Mattsson, T., Sasaki, N. and Wilkman, G., 2002. *The Development of the Double Acting Tanker for Ice Operation*. Okhotsk Sea & Sea Ice Conference, Mombetsu, Japan, 24–28 February 2002. Available from: <http://www.akerarctic.fi/publications/pdf/MombXDat.pdf> [Accessed 7 January 2010].
- Kitagawa, H. ed., 1996. *Northern Sea Route; Future & Perspective*. The Proceedings of INSROP Symposium Tokyo '95, 1–6 October 1995. Tokyo: Ship and Ocean Foundation.
- Kitagawa, H. (kitasanh@jasmine.ocn.ne.jp), 26 March 2008a, RE: Blank. Email to D. Brubaker (douglas.brubaker@fni.no).
- Kitagawa, H. (kitasanh@jasmine.ocn.ne.jp), 3 May 2008b, RE: Blank. Email to D. Brubaker (douglas.brubaker@fni.no).
- Moe, K.A. and Semanov, G.N., 1999. Environmental Assessments. In: W. Østreng et al. eds. *The Natural and Societal Challenges of the Northern Sea Route – A Reference Work*. Dordrecht, The Netherlands: Kluwer Academic Publishers, 121–220.

Østreng, W., chief ed., Kitagawa, H., and Peresytkin, V.I., eds., 1999a. *The Natural and Societal Challenges of the Northern Sea Route – A Reference Work*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Østreng, W., Kolodkin, A.L., Brubaker, D. and Jernsletten, J.L., 1999b. Military, Political, Legal and Human Affairs. In: W. Østreng *et al.* eds. *The Natural and Societal Challenges of the Northern Sea Route – A Reference Work*. Dordrecht, The Netherlands: Kluwer Academic Publishers, 281–363.

Østreng, W., 1999. Multiple Realities of the NSR: Geographical Hot and Cool Spots of Navigation. In: W. Østreng *et al.* eds. *The Natural and Societal Challenges of the Northern Sea Route – A Reference Work*. Dordrecht, The Netherlands: Kluwer Academic Publishers, 365–426.

Ragner, C.L. ed., 2000. The 21st Century – Turning Point for the Northern Sea Route? Proceedings from the Northern Sea Route User Conference, Oslo, 18–20 November 1999. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Rules of Navigation – Regulations for navigation on the seaways of the NSR, 1996. In: *Guide to Navigating through the Northern Sea Route*. St. Petersburg: Head Department of Navigation and Oceanography of the Ministry of Defence of the Russian Federation, 80–84.

Santos-Pedro, V., 2004. Arctic Shipping Rules: the Climate is.... a-Changin'. In: L. Brigham and B. Ellis, eds., *Arctic Marine Transport Conference, Scott Polar Research Institute, Cambridge University, U.K., 28–30 September 2004*, p. A-14. Available from: <http://www.institutenorth.org/servlet/download?id=123> [Accessed 7 January 2010].

Tamvakis, M., Granberg, A.G. and Gold, E., 1999. Economy and Commercial Viability. In: W. Østreng *et al.* eds. *The Natural and Societal Challenges of the Northern Sea Route – A Reference Work*. Dordrecht, The Netherlands: Kluwer Academic Publishers, 221–280.

What is Azipod [online], 2006. Zürich, ABB. Available from: <http://www.abb.com/cawp/db0003db002698/b4c6f2757969bba6c12571f100410217.aspx> [Accessed 7 January 2010].

Yamaguchi, H., 1996. Experimental Voyage through Northern Sea Route. In H. Kitagawa, ed. *Northern Sea Route; Future & Perspective. The Proceedings of INSROP Symposium Tokyo '95, 1–6 October 1995*. Tokyo: Ship and Ocean Foundation, 39–90.

Notes

¹ INSROP homepage, at <http://www.fni.no/insrop/>.

² By 1993–98 exchange rates this equalled approximately USD 8–9 million.

³ INSROP statistics are summarized in the *INSROP Programme Report* (INSROP Secretariat, 1999)

⁴ INSROP's early history and organization are described in the very first issue of the *INSROP Newsletter* (INSROP Secretariat, 1993).

⁵ Adapted from Brigham, *et al.* (1999), pp. 116–120 and Østreng (1999), pp. 414–418. Comments and technical editing are added by Professor Hiromitsu Kitagawa, author and editor of this section.

⁶ Respectively, European Remote Sensing Satellite (ERS) and Radar Satellite (RADARSAT) system. The latter was developed by Canada to monitor global environmental changes. In addition the European Environmental Satellite (ENVISAT) launched in 2002 is the largest earth observation spacecraft providing continuous observations and monitoring of the Earth's land, atmosphere, oceans and ice caps. (Gold 2008).

⁷ The prediction holds as long as the definition of ice classification was applied to ice age, ie. first year ice, multi year ice or ice extent. Satellite images could not alone provide reliable or satisfactory information of appropriate vessel routings, and captains of vessels needed considerable experience in analysing satellite images for obtaining useful information related to routings. (Kitagawa 2008a).

⁸ For more information on the Azipod propulsion system, see *What is Azipod* (2006).

-
- ⁹ Statistic data of vessel damage is one of the key factors governing the development of safe vessels, navigations, ship structure, regulations and marine insurance. Damage data includes items such as date, time, wind and waves, location, particulars of ship, vessel speed, damage details, and captain's comments. The INSROP data received was rather ambiguous, and there were problems trusting the published Russian vessel damage data that occurred during the Soviet era. It appeared captains expected a high possibility for vessel damage occurring; it was the nature of things. Close-towing which was a particular Russian manner of escorting cargo vessels required much skill of the captains of the escorting and escorted vessels, and this could partly be responsible for the damage occurring under icebreaker escort. However the Russians would not admit to such damage occurring. Further, vessel damage often occurred on the NSR at the end of the summer season. Under INSROP the Russians were requested many times to release reliable statistical data of vessel damage, but the requests were refused. (Kitagawa 2008a, 2008b).
- ¹⁰ The Conference on the Harmonisation of Polar Ship Rules led to the development of the recommendatory IMO *Guidelines for Ships Operating in Arctic Ice-covered Waters* (Arctic Guidelines) (IMO 2002), in 2009 modified to become *Guidelines for Ships Operating in Polar Waters* (Polar Guidelines) (IMO 2009), as well as the International Association of Classification Societies (IACS) *Unified Requirements for Polar Ships* (IACS 2007), to be uniformly applied by IACS Societies on ships contracted for construction on and after 1 March 2008. According to Det Norske Veritas' Senior Vice President W. Magelssen (personal communication, 26 January 2007), this contains polar class descriptions and application, structural requirements, and machinery requirements, however, allow each member society a certain amount of discretion, and polar class vessels may thus still be certified under different sets of rules. Owners of new vessels may choose whether the unified IACS requirements will be utilised or the specific society requirements. For descriptions of the initial conference process see Santos-Pedro (2004).
- ¹¹ Under § 1.7 the Marine Operation Headquarters is defined as special navigational services of the Murmansk and Far East Shipping Companies, directly performing ice operations on the NSR, under the general co ordination by the Administration. Under § 1.3 the Administration is defined as the Administration of the NSR of the U.S.S.R. (Russian Federation) Ministry of Merchant Marine, established by the U.S.S.R. Council of Ministers Decision No. 683 of 16 September 1971, and having its location at ¼ Rozhdestvenka, Moscow, 103759 U.S.S.R. (Russian Federation).
- ¹² ULA is the Russian Registry designation for the highest ice able class of vessel, including the *Noril'sk*. (This footnote added by the authors.)
- ¹³ See Juurmaa *et al.* (2002).
- ¹⁴ Østreng (1999), p. 417, cites <http://www.pmel.noaa.gov/bering>, available from 31 December 1998, which does not appear available now (access attempt 7 January 2010).
- ¹⁵ Østreng (1999), p. 417, cites AMAP (1997), *Arctic Pollution Issues: A State of the Arctic Environment Report*. Oslo: Arctic Monitoring and Assessment Programme, 159–169. Ibid. p. 116 notes, based upon Russian reports, large seasonal and interannual changes of sea ice in the Russian Arctic seas during the 20th century. This included from approximately 1900-1945 a general warming of the Arctic resulting in exploration of the NSR, 1945-1985 a general cooling with difficult ice conditions and in the final decade significant regional reductions in sea ice particularly in the East Siberian Sea.
- ¹⁶ Adapted from Moe and Semanov (1999), pp. 210–14 and Østreng (1999), p. 421. Comments are added by Environmental Consultant Kjell A. Moe author and programme leader of this section.
- ¹⁷ ArcView is GIS software for visualizing, managing, creating, and analyzing geographic data.
- ¹⁸ ArcInfo is GIS which adds to ArcView advanced spatial analysis, extensive data manipulation, and high-end cartography. UNIX is a trademarked computer operating system.
- ¹⁹ Persistent organic pollutants are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this they have been observed to persist in the environment, to be capable of long-range transport, bio accumulate in human and animal tissue, bio magnify in food chains, and to have potential, significant impacts on human health and the environment.
- ²⁰ *Polynyas* are stretches of open water surrounded by ice.
- ²¹ Trophic level is each of several hierarchical levels in an ecosystem comprising organisms sharing the same function in the food chain and the same nutritional relationship to the sources of energy.
- ²² For discussion see Moe and Semanov (1999), p. 216. An overview of World Bank Projects in Russia is available at: <http://web.worldbank.org/external/projects/main?pagePK=217672&piPK=95916&theSitePK=40941&menuPK=223661&category=regcountries®ioncode=5&countrycode=RU&pagenumber=1&pagesize=50&totalrecords=91&sortby=BOARDSORTDATE&sortorder=DESC> [Accessed 7 January 2010]. While mention is made of the checklists, as related to mitigating measures for relevant activities and developments covering the NSR these did not appear to be now available.
- ²³ Adapted from Tamvakis *et al.* (1999), pp. 278–80 and Østreng (1999), pp. 419 and pp. 423–424. Comments and technical editing are added by Professor Edgar Gold, one of the authors of this section.
- ²⁴ Both the International Underwriting Association (IUA) and the Salvage Association are based in London.

²⁵ Adapted from Østreng *et al.* (1999b), pp. 334–336, pp. 349–355, pp. 359–361 and pp. 362–363 and Østreng (1999), p. 365, generally pp. 366–413 and pp. 422–425. Specific authors of Østreng *et al.* (1999b) are identified as W. Østreng, lead author responsible for pp. 281–314, pp. 337–339, and pp. 362–363, as well as editing; A.L. Kolodkin, responsible for pp. 314–325; D. Brubaker, responsible for pp. 326–336; and J.L. Jernsletten, responsible for pp. 339–361. Comments and technical editing are added by Dr. R. Douglas Brubaker, programme leader of this section.

²⁶ The Russian Arctic straits were not entered by the U.S. vessels.

²⁷ Natural and societal parameters were linked together to better address the complexity, distribution, variability, interactional pattern and value composition of the navigational challenges facing the NSR. The objective was to identify geographical areas where the parameters multiply, mix, interact and cluster together in aggregations, making the passage of vessels a complex, multi faceted challenge, with these areas termed *aggregated hot spots*. The Kara, Laptev, East Siberian and Chukchi Seas are addressed as well as the multiple realities of the NSR. The Table ‘Qualitative assessment of the geographical location of issue specific hot spots, aggregated hot spots and cool spots along the NSR’ appears at Østreng (1999) pp. 406–407 as well as Maps ‘Geographical spots of varying navigability along the whole stretch of the NSR winter/summer,’ at Østreng (1999) pp. 409–410.